SUMMER ICHTHYOPLANKTON ASSEMBLAGES IN THE EASTERN BERING SEA 2001-2007

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Assemblages

Species co-occuring spatially and temporally
Also referred to by some as “communities”

Is this just random coincidence or the result of biological or physical influences? Perhaps a interaction of both?

Biological

Spawning location and timing

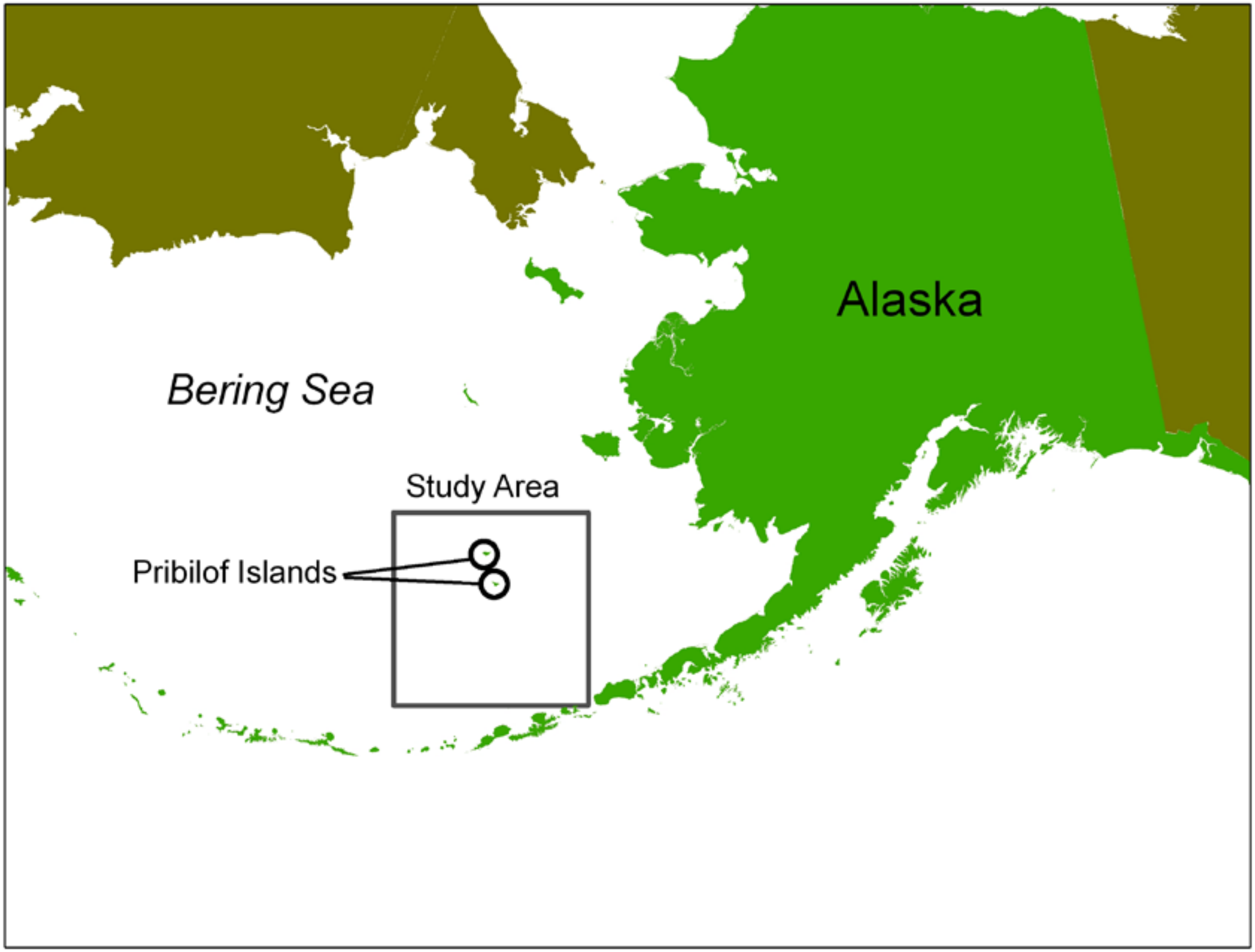
Availability of food

Presence/absence of predators

Physical

Circulation patterns/ currents, eddies etc

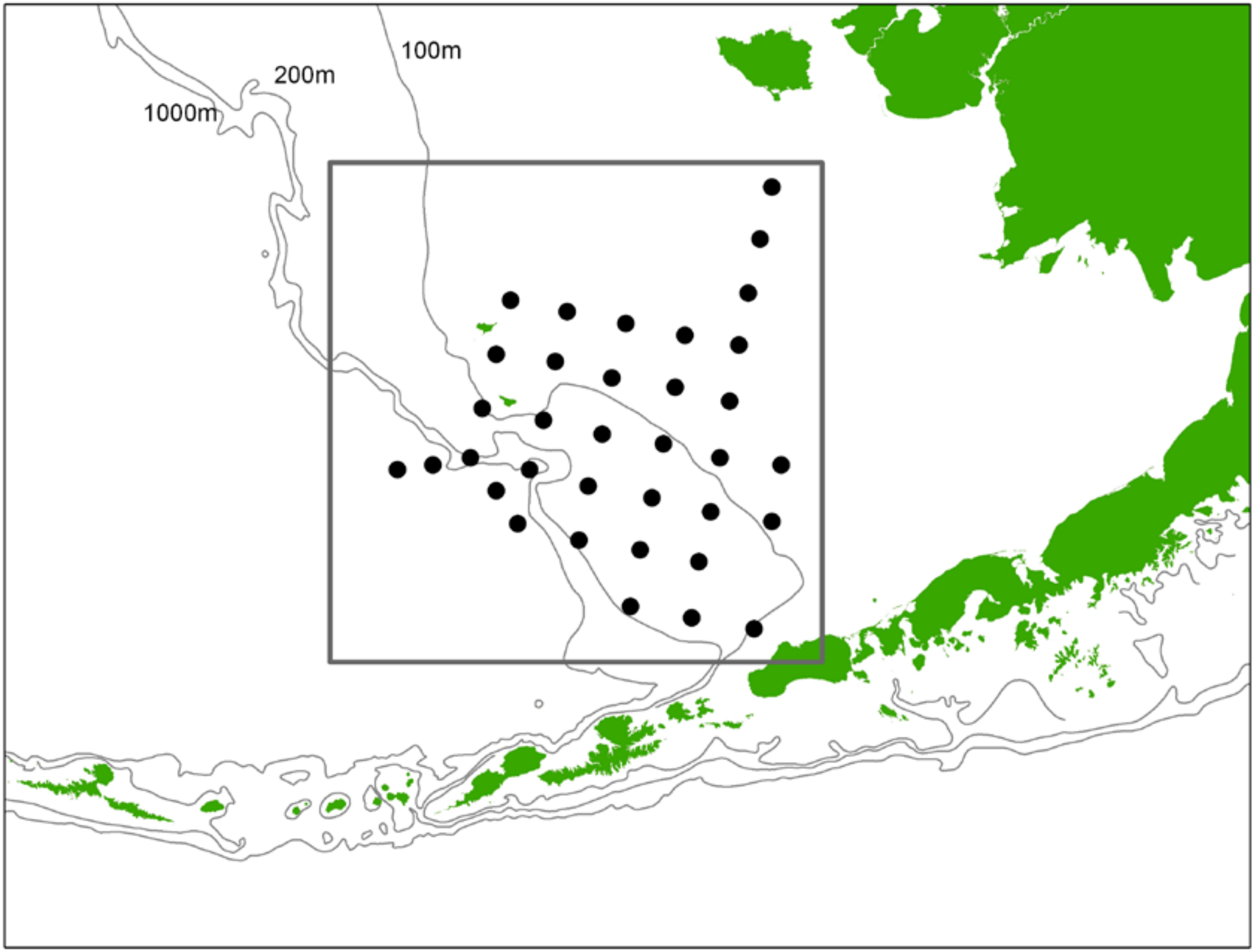
Fronts/temperature, salinity barriers


Alaska
Bering Sea
Study Area
Pribilof Islands

T/V *Oshoro Maru*

Summers of 1995-2007*

*Late July-early Aug - 2nd longest FOCI ichthyoplankton time series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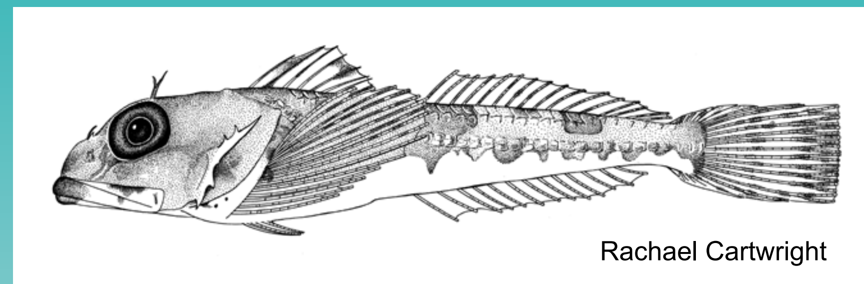
200m
1000m

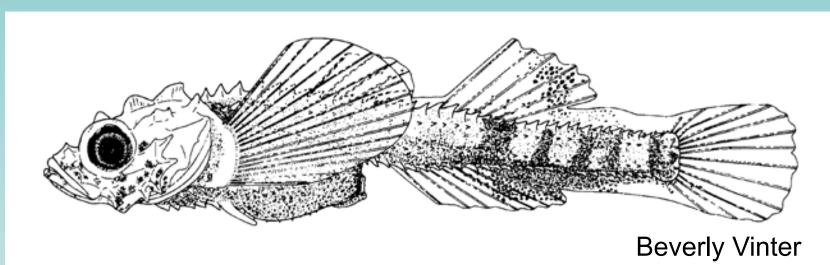
Transformation – Morphology
Behavior

Another “critical period”

Theragra chalcogramma (40.0 mm SL)
Walleye pollock

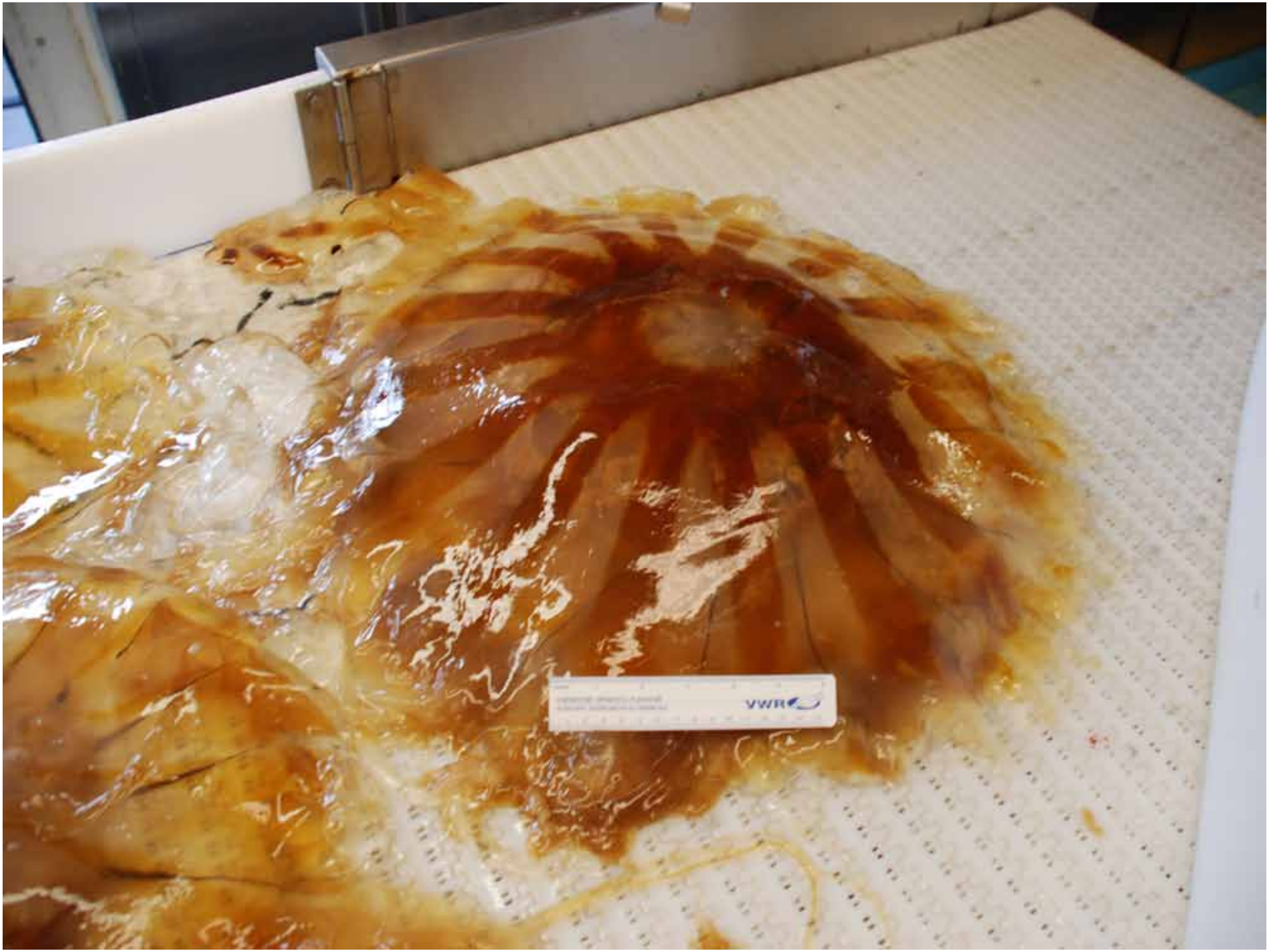


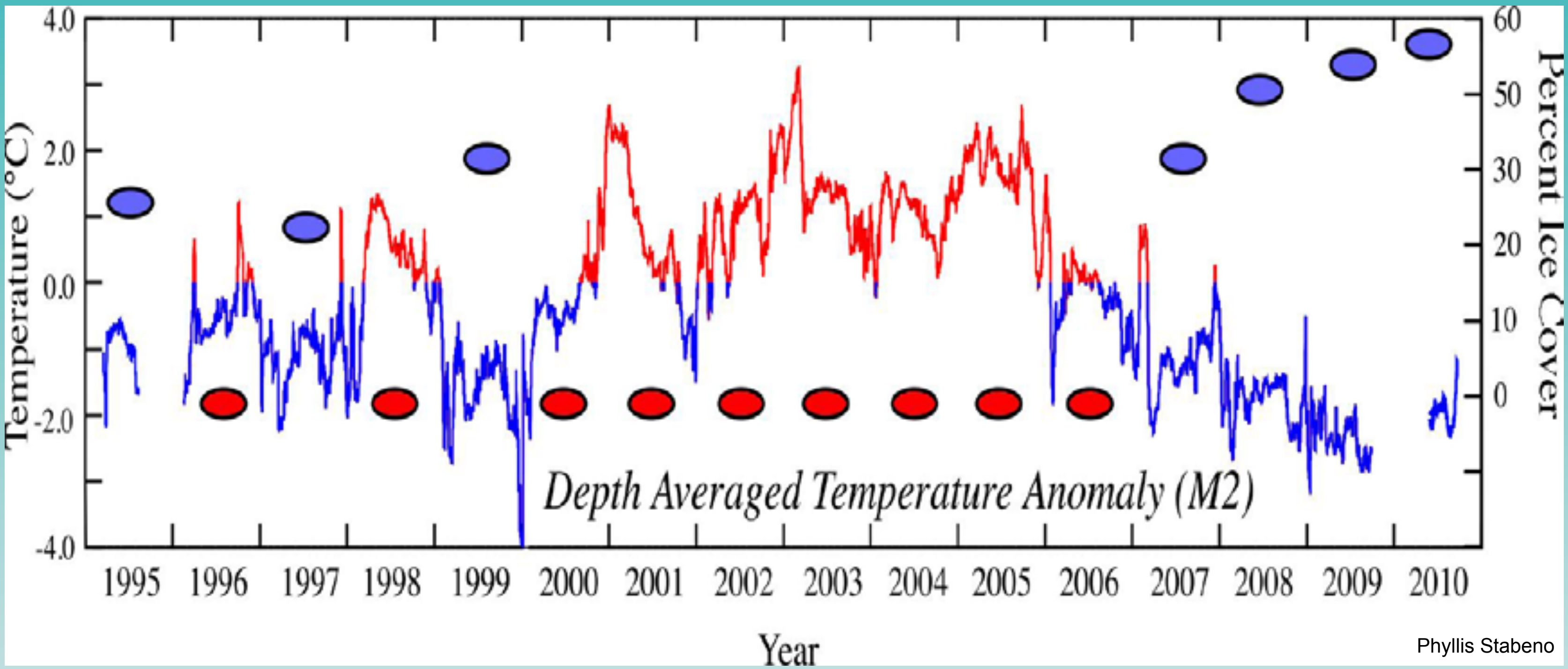
Icelinus borealis (41.7 mm SL)
Northern sculpin



Bathyagonus alascanus (14.3 mm SL)
Gray starsnout

Reinhardtius hippoglossoides (72.0 mm SL)
Greenland halibut


VWR



4.0
2.0
0.0
-2.0
-4.0
Temperature (°C)
60
50
30
20
10
0
Percent Ice Cover
Depth Averaged Temperature Anomaly (M2)
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year
Phyllis Stabeno

 Fish. Oceanogr. 15:1, 80–94, 2006

Spatial and temporal patterns in summer ichthyoplankton assemblages on the eastern Bering Sea shelf 1996–2000

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ABSTRACT

Larval and early juvenile fishes were sampled from the eastern Bering Sea (EBS) shelf during summer from 1996 to 2000. Data from these collections were used to examine spatial and temporal patterns in species assemblage structure and abundance. Cluster analyses based on Bray–Curtis dissimilarity coefficients were used to group species and stations according to similar abundance and species composition. Ordination techniques were used to verify groupings, and a non-parametric stepwise procedure using a Spearman correlation coefficient (BIO-ENV) was used to relate groupings to predominant environmental variables. These approaches revealed a pattern of station groupings that were generally related to bathymetry in 1996, 1997, 1999, and 2000, although no obvious relationship to geographic boundaries was observed in 1998. Significant differences in species associations were observed in 1997 and 1998, and depressions in abundance were also noted among many species between 1997 and 1999. A regional, full primitive equation model was used to simulate float trajectories on the EBS shelf in each year to better relate fish distributional observations to prevailing current patterns. Model results indicated general variations in flow in several years, although 1998 stood out with stronger northeast flow than in any of the other years examined. Observed disruptions of larval and early juvenile fish assemblages could be related to the strong El-Niño event of 1997–98 in the EBS. If this idea is confirmed, our study suggests that larval and juvenile fish are sensitive and respond relatively quickly (1–2 yr) to environmental perturbations, and as such, may be timely indicators of environmental change.

Key words: assemblages, Bering Sea, El Niño, fish larvae, juveniles, spatial distribution

INTRODUCTION

Ichthyoplankton assemblages may be the result of 'adaptive convergence' (McGowen, 1993), whereby larvae of different species tend to co-occur as a result of parallels in their life histories. For example, similarities in the reproductive patterns of adults (Gray and Miskiewicz, 2000), exposure to similar hydrographic processes such as currents or upwelling (Smith and Suthers, 1999), or convergence with a similar resource such as abundant zooplankton (Moser and Smith, 1993) can all lead to discrete groupings of co-occurring larval fish species. In addition, ichthyoplankton assemblages have been shown to be distinct within oceanographic regions (e.g. water masses) and respond to environmental change (Moser *et al.*, 1987). However, these associations are not fixed in time or space; rather, they are flexible and by their nature, sensitive to external perturbations. The degree of distortion varies: small-scale disturbances in time and space such as variations in local turbulence, upwelling, or instabilities in currents have short-lived impacts on assemblages, briefly disrupting them, but allowing their constituents to re-form relatively quickly after the perturbation has passed. Large-scale stresses such as climate variation (e.g. Pacific Decadal Oscillation, Arctic Oscillation, or climate change) potentially have the ability to break associations completely (Anderson and Piatt, 1999), prompting a distinct, long-term reorganization of community dynamics. We were interested in determining the degree of impact a meso-scale event, specifically the 1997–98 El Niño, had on associations of larval and early-stage juvenile fishes in the eastern Bering Sea (EBS). Other studies have examined the effects of El Niño on distribution and abundance of temperate larval fishes along the US

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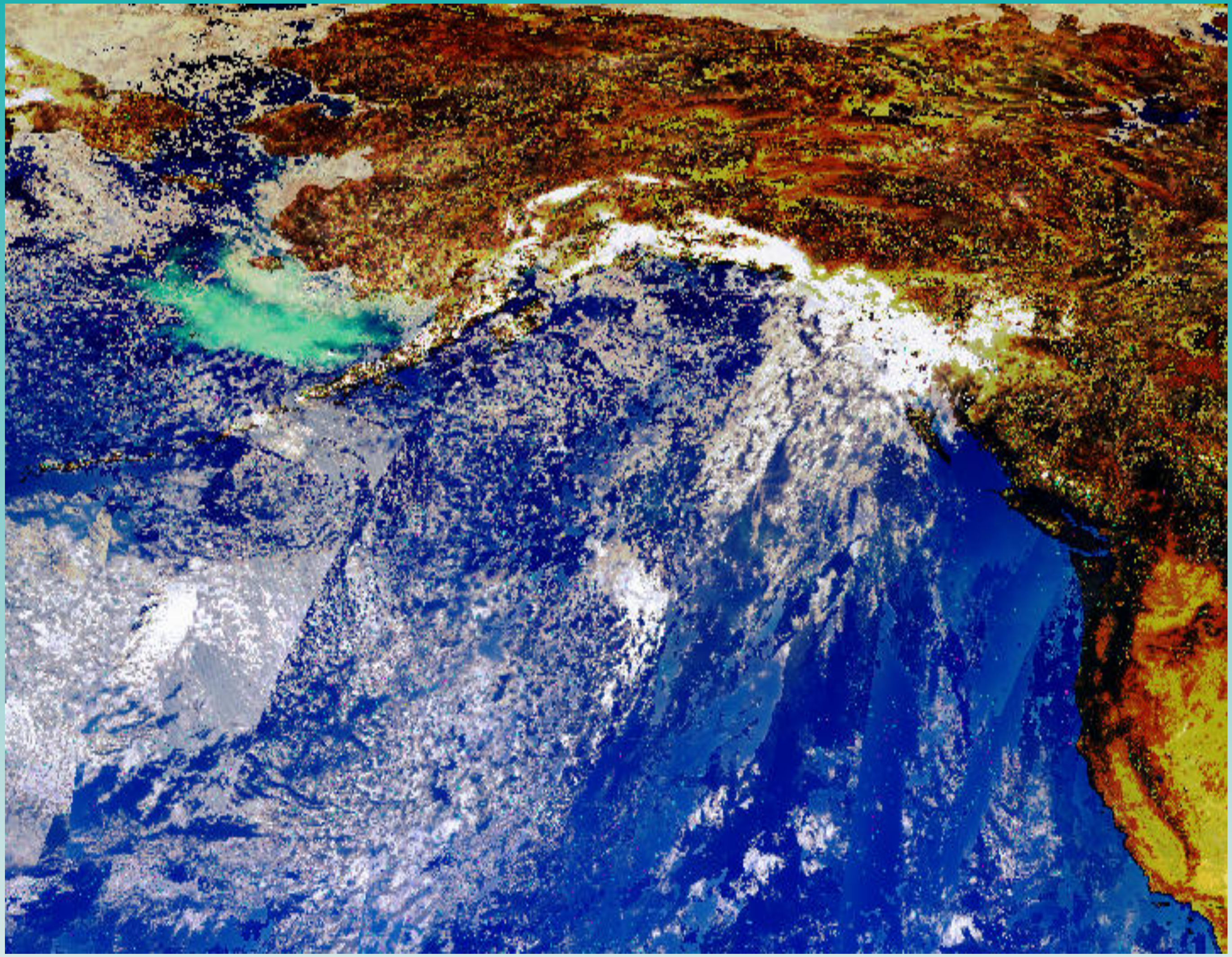
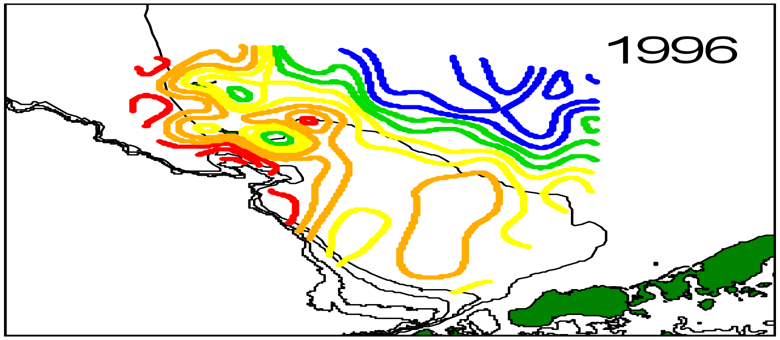
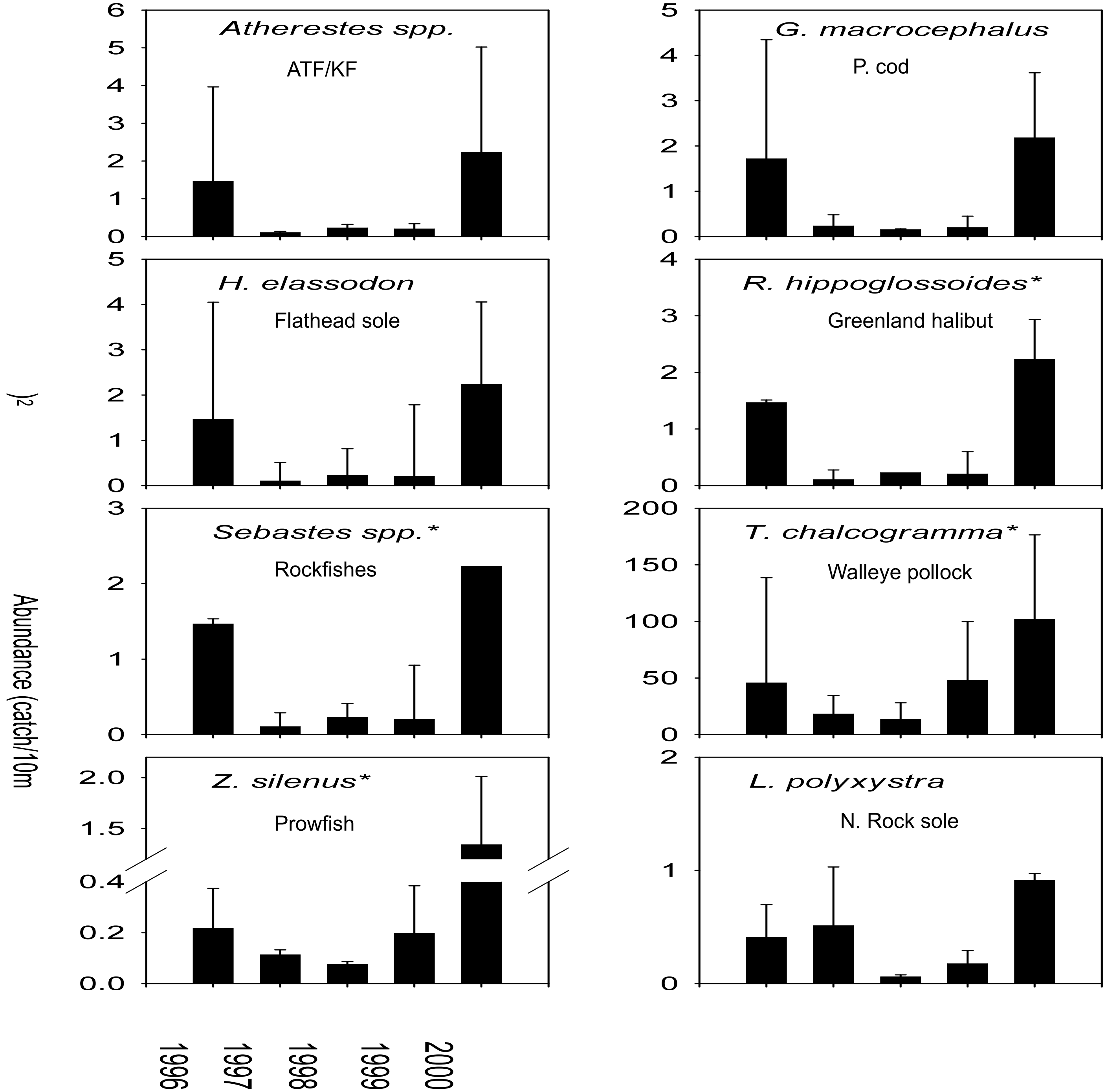
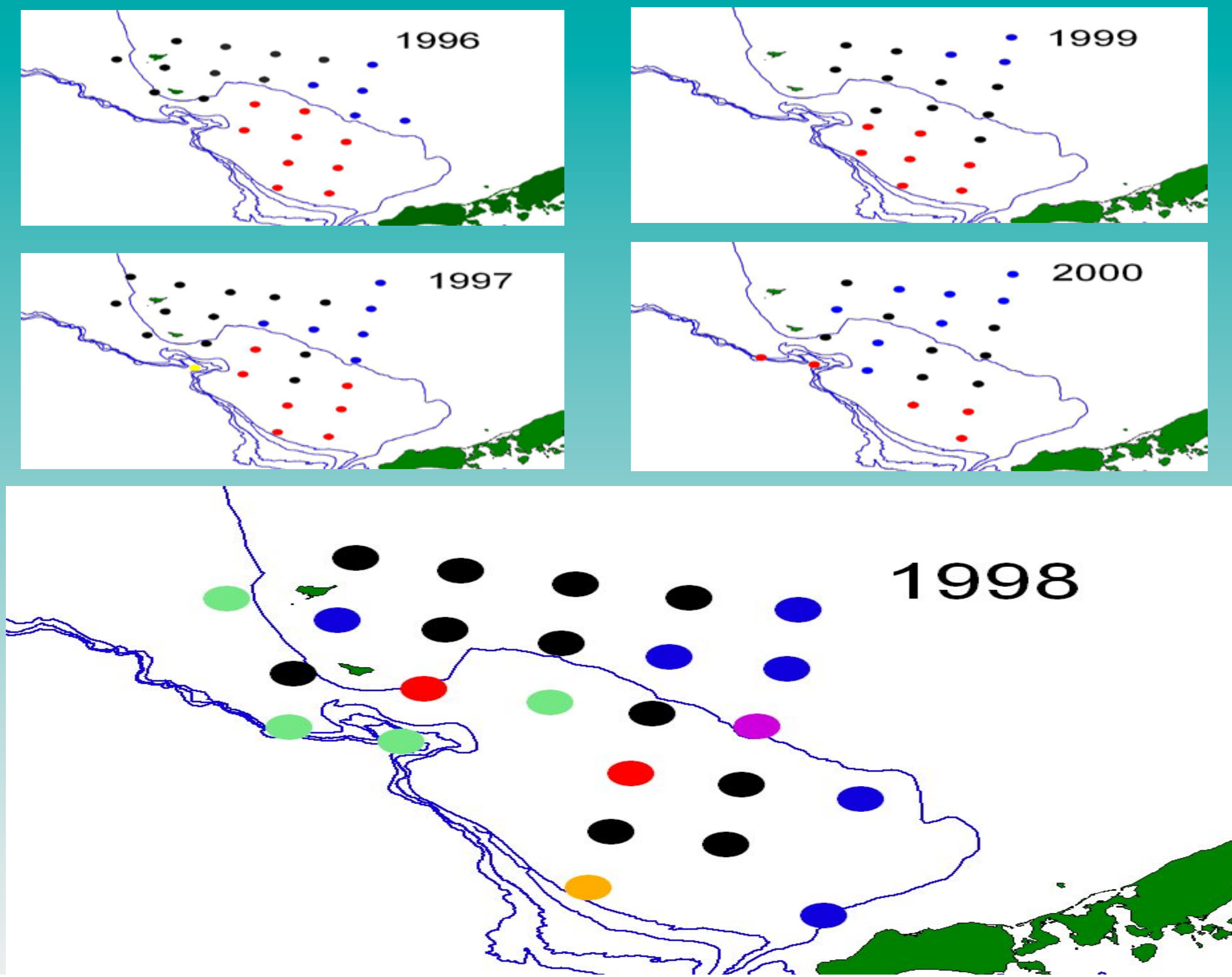
Agenda

- Brief summary of the 1996-2000 study results
- Present some preliminary results of our 2001-2007 (minus 2006) work
- Compare results from the first and second study periods
- Questions & Maybe answers
- Share some photos taken over the course of these investigations




1996


Atherestes spp.
ATF/KF
G. macrocephalus
P. cod
H. elassodon
Flathead sole
R. hippoglossoides*
Greenland halibut
Sebastes spp.*
Rockfishes
T. chalcogramma*
Walleye pollock
Z. silenus*
Prowfish
L. polyxystra
N. Rock sole
Abundance (catch/10m)2
1996
1997
1998
1999
2000


1996
1999
1997
2000
1998

Conclusions (previous study)

- General patterns of ichthyoplankton assemblages related to bathymetry
- 1998 showed anomalous assemblage structure
- Was likely related to El Niño events of 1997-1998
- Probably affected distribution of spawning adults in 1998
- Ichthyoplankton assemblage srtucture on the EBS shelf is influenced by atmospheric forcing and circulation patterns

Objectives (present study)

- Describe summer larval and juvenile fish assemblages on the EBS shelf
- Examine interannual variations in assemblages
- Relate observations to oceanographic conditions

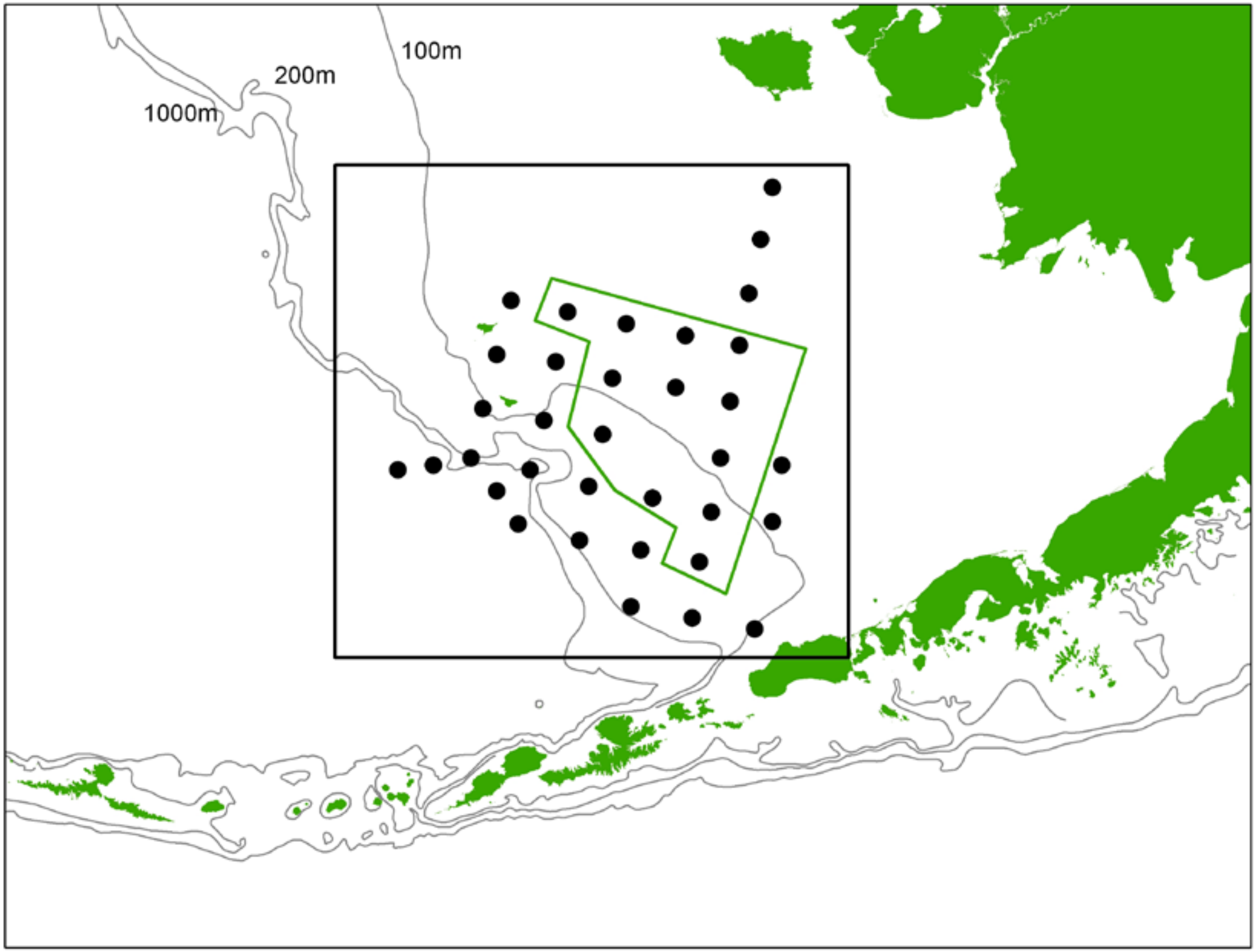
Analytical approaches

Data from 2001-2007 (2006 omitted)

Multivariate analyses used to examine species assemblages

- Cluster analyses
- NMDS
- ANOSIM

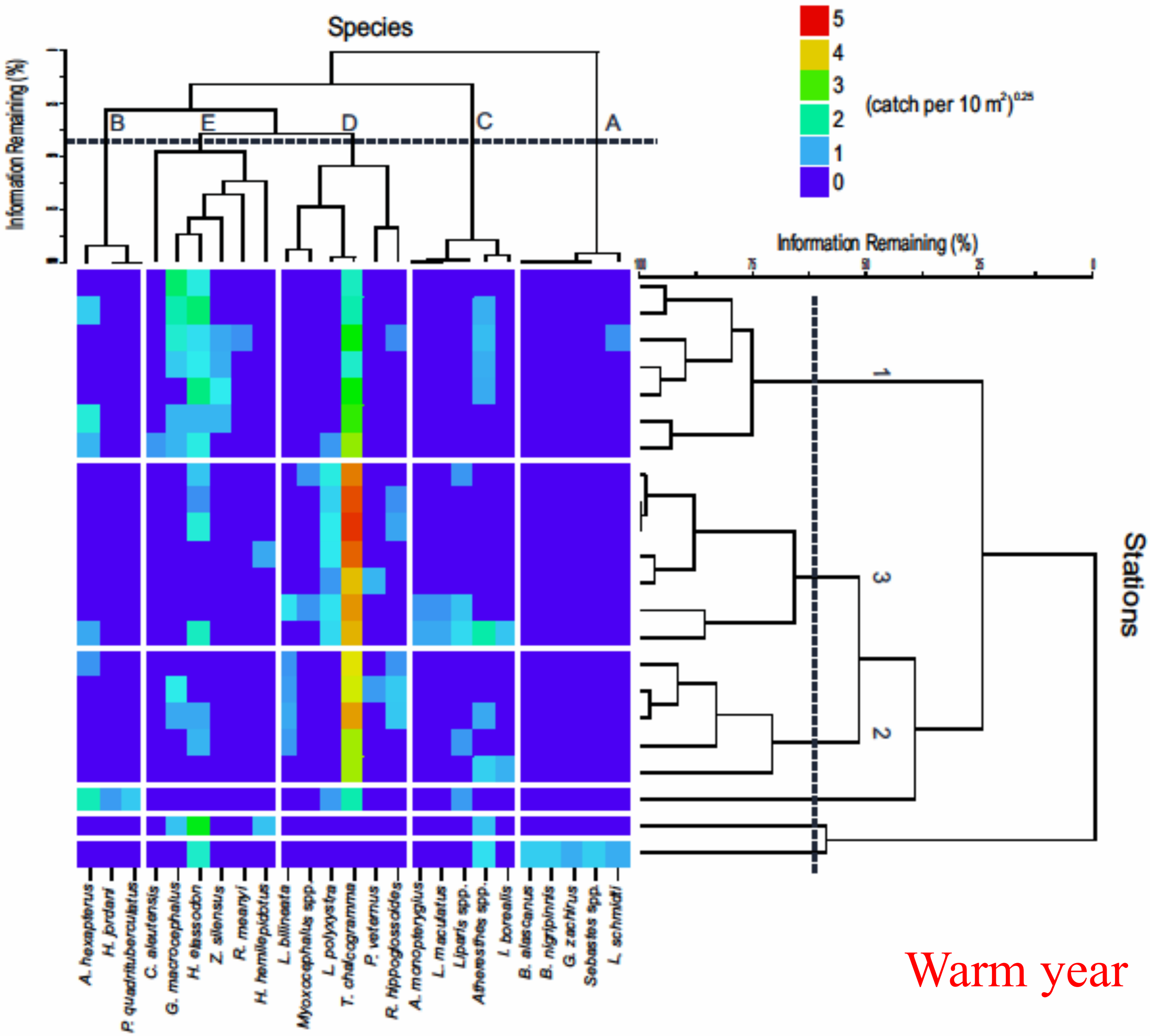
Univariate ANOVA's to test for differences between years (abundance and length for 7 most abundant species all years)


100m
200m
1000m

Species List

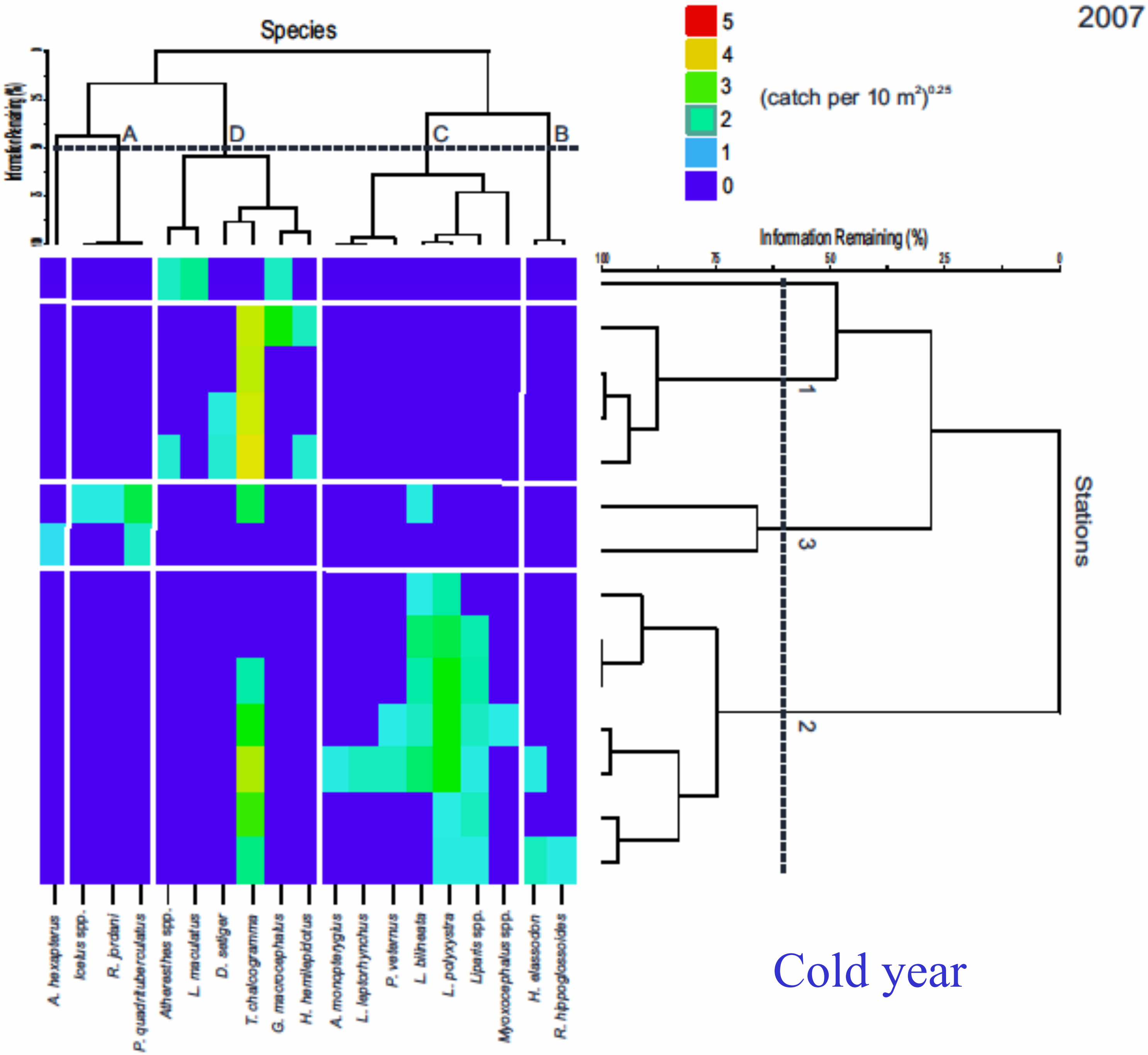
based on occurrence in 4% or more of all samples

Species name	Common name	2001	2002	2003	2004	2005	2007
Bathylagidae							
Leuroglossus schmidti	Northern smoothtongue	X	X		X	X	
Gadidae							
Gadus macrocephalus	Pacific cod	X	X	X	X	X	X
Theragra chalcogramma	Walleye pollock	X	X	X	X	X	X
Scorpaenidae							
Sebastes spp.	Unidentified rockfishes	X	X	X	X	X	
Cottidae							
Hemilepidotus hemilepidotus	Red Irish lord	X	X	X		X	X
Icelinus borealis	Northern sculpin	X				X	
Myoxocephalus spp.	Unidentified sculpin	X		X		X	X
Psychrolutidae							
Dasycottus setiger	Spinyhead sculpin				X	X	X
Agonidae							
Aspidophoroides monopterygius	Alligatorfish	X			X	X	X
Bathyagonus alascanus	Gray starsnout	X	X	X	X	X	
Podothecus veternus	Veteran poacher			X	X	X	X
Liparidae							
Liparis spp.	Unidentified snailfishes	X	X	X	X	X	X
Stichaeidae							
Lumpenus maculatus	Daubed shanny	X	X	X	X	X	X
Zaproridae							
Zaprora silenus	Prowfish	X	X	X	X	X	
Ammodytidae							
Ammodytes hexapterus	Pacific sand lance	X	X	X	X	X	X
Pleuronectidae							
Atheresthes spp.	Arrowtooth/Kamchatka flounder	X	X	X	X	X	X
Hippoglossoides elassodon	Flathead sole	X	X	X	X	X	X
Lepidopsetta bilineata	Southern rock sole	X	X		X	X	X
Lepidopsetta polyxystra	Northern rock sole	X	X	X	X	X	X
Reinhardtius hippoglossoides	Greenland halibut	X	X		X	X	X
Total (including those not used in analyses)		25	18	18	23	28	21

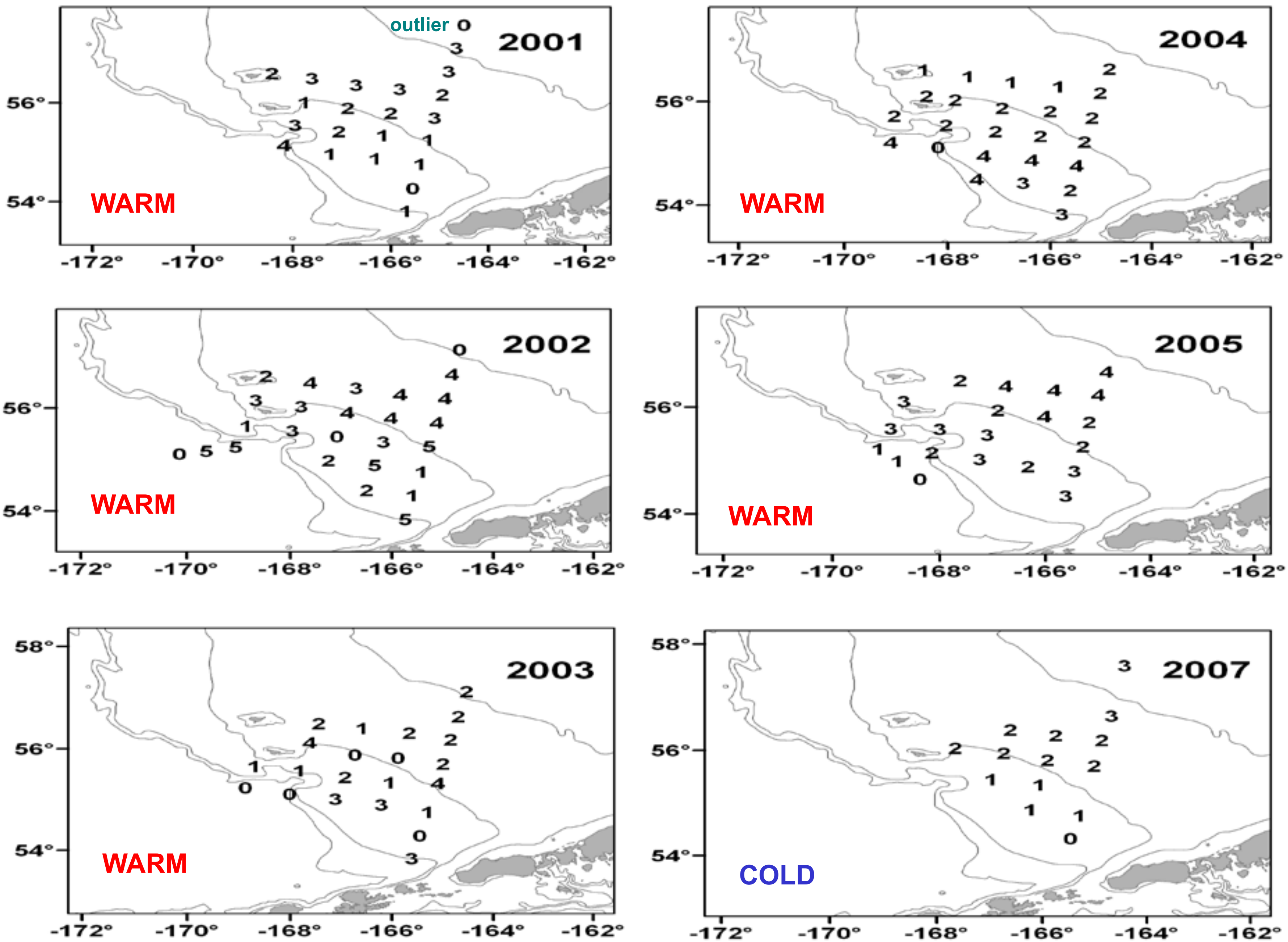


2001

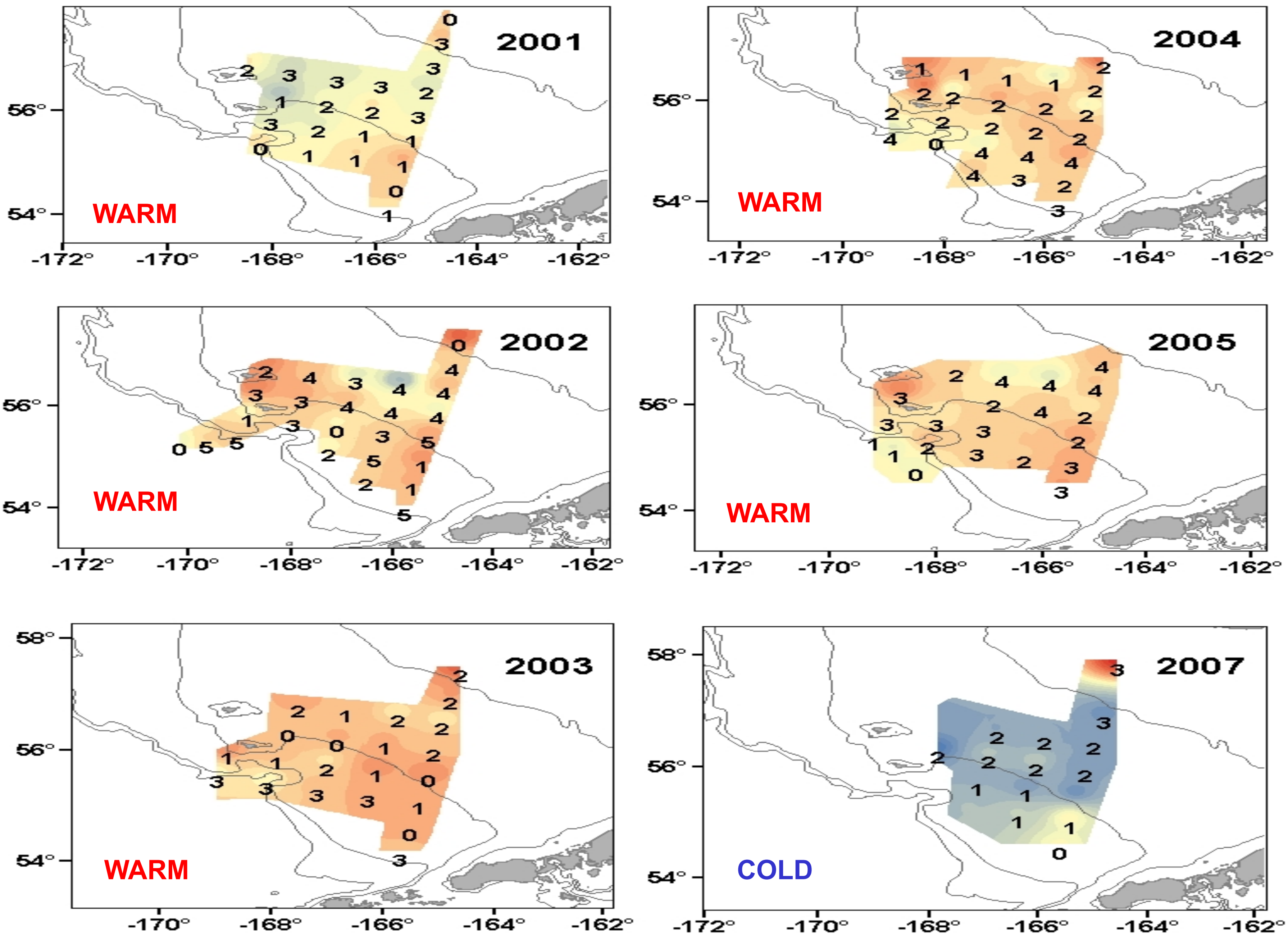
Warm year


2007
Species
A
D
C
B
5
4
3
2
1
0
(catch per 10 m²)^0.25
Information Remaining (%)
100
75
50
25
0
1
3
2
Stations
A. hexapterus
Icelus spp.
R. jordani
P. quadrituberculatus
Atheresthes spp.
L. maculatus
D. setiger
T. chalcogramma
G. macrocephalus
H. hemilepidotus
A. monopterygius
L. leptorhynchus
P. veternus
L. bilineata
L. polyxystra
Liparis spp.
Myoxocephalus spp.
H. elassodon
R. hippoglossoides

Cold year



outlier
2001
WARM
2004
WARM
2002
WARM
2005
WARM
2003
WARM
2007
COLD
58°
56°
54°
-172°
-170°
-168°
-166°
-164°
-162°


2001
WARM
2004
WARM
2002
WARM
2005
WARM
2003
WARM
2007
COLD
58°
56°
54°
-172°
-170°
-168°
-166°
-164°
-162°

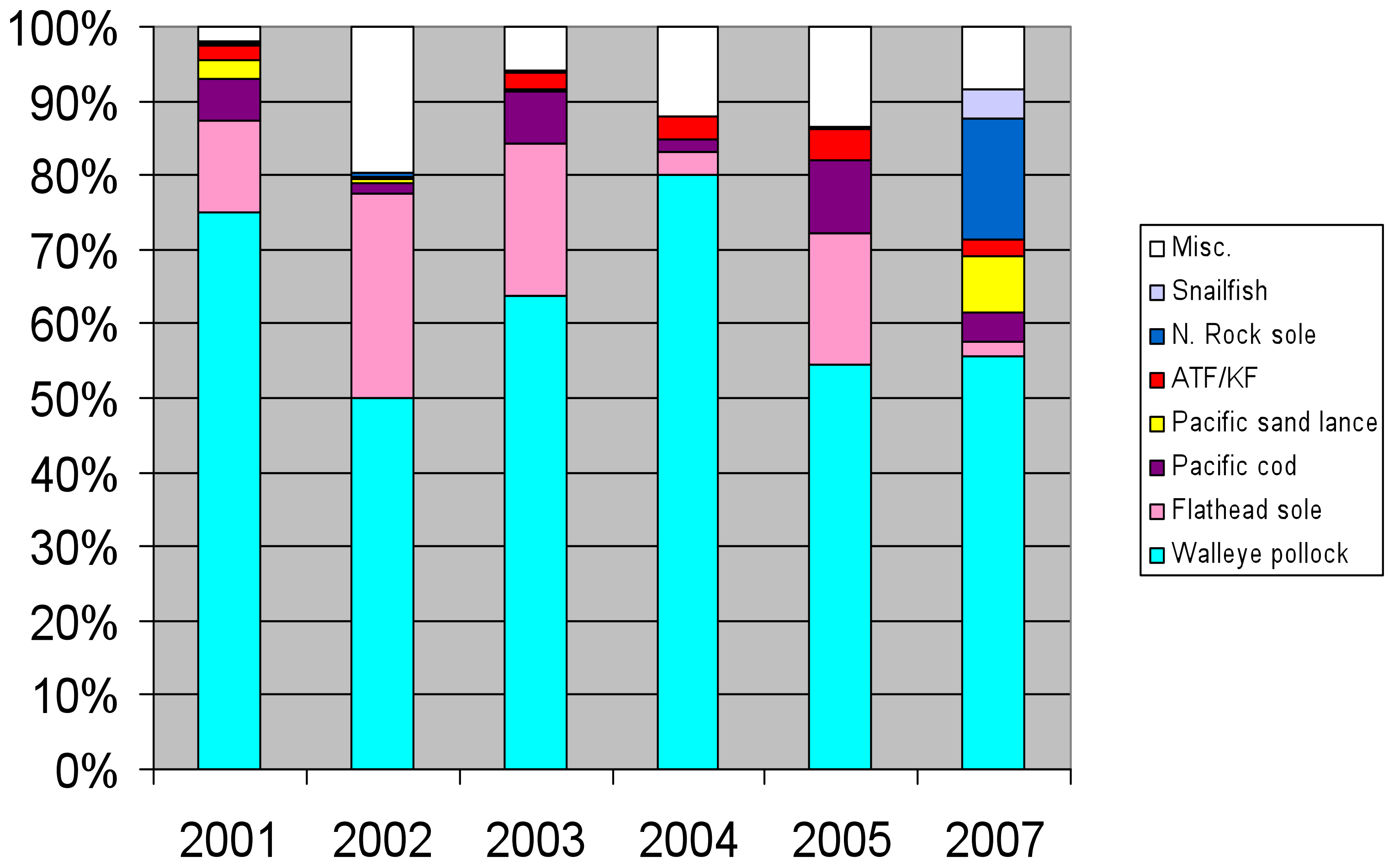
ANOSIM – Analysis of similarity

2001 and 2007 were significantly different from each other ($p=0.001$, $R=0.67$) and all other years ($p \leq 0.02$, $R \geq 0.19$) in species composition

SIMPER – Similarity Percentage Analysis

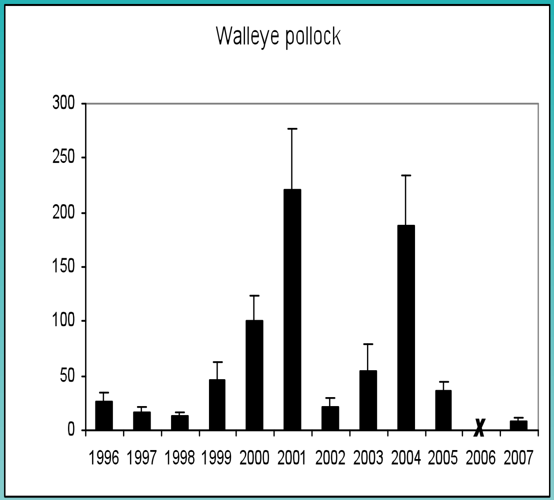
Identifies what species contributed most to the observed differences.

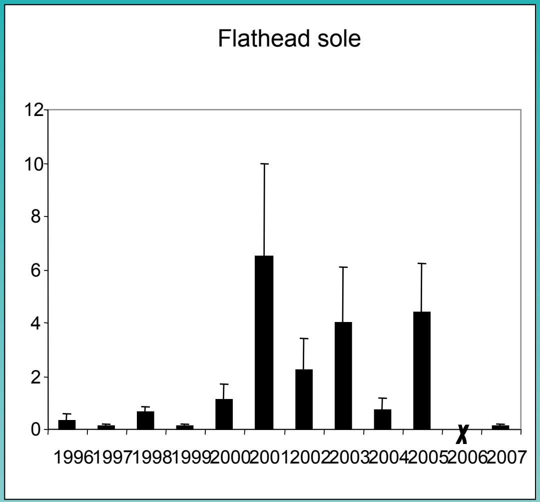
Average % Composition of Top 7 Species

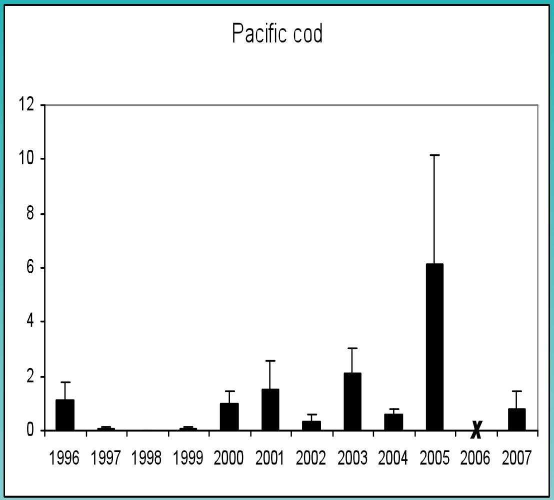


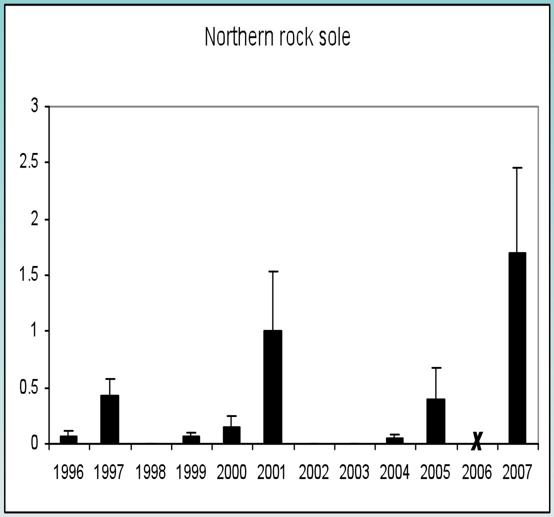
Abundance (Number/10m^2)

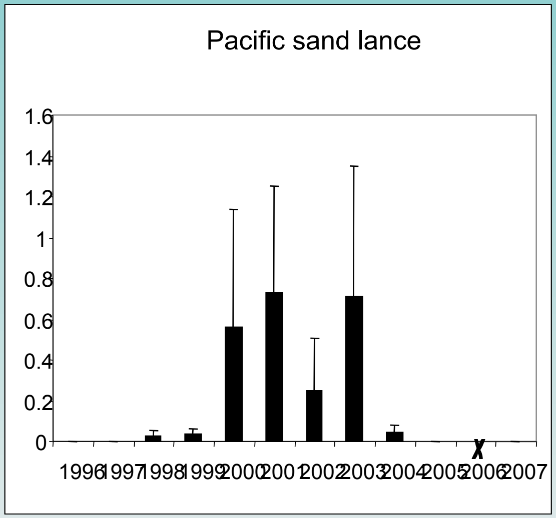
common stations only

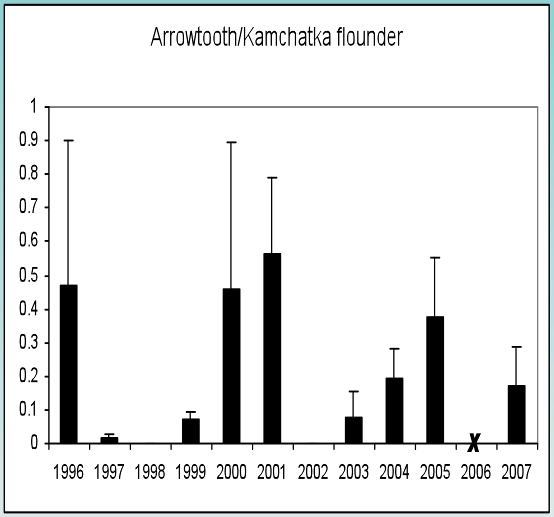












Significant differences in interannual abundance of the seven most commonly collected species/taxa within the 'core' group of stations

Species	2001	2002	2003	2004	2005	2007
Walleye pollock	C	AB	B	C	B	A
Flathead sole	B	AB	B	AB	B	A
Pacific cod	AB	A	B	B	B	A
N. rock sole	BC	A	A	A	AB	C
Pacific sand lance	A	A	A	A	A	A
ATF/KF	B	A	AB	AB	B	A
Snailfishes	A	A	A	A	A	A

Different letters indicate significant difference ($P<0.05$), like letters indicate no significant difference.

A indicates years with lowest means within that species.

C (or B) indicates highest means within that species.

ANOVA – Abundance

- Walleye pollock in 1998 and 2007 were significantly lower in abundance than all other years ($p < 0.02$) and greater than all others in 2001 and 2004 except 2000 ($p < 0.03$)

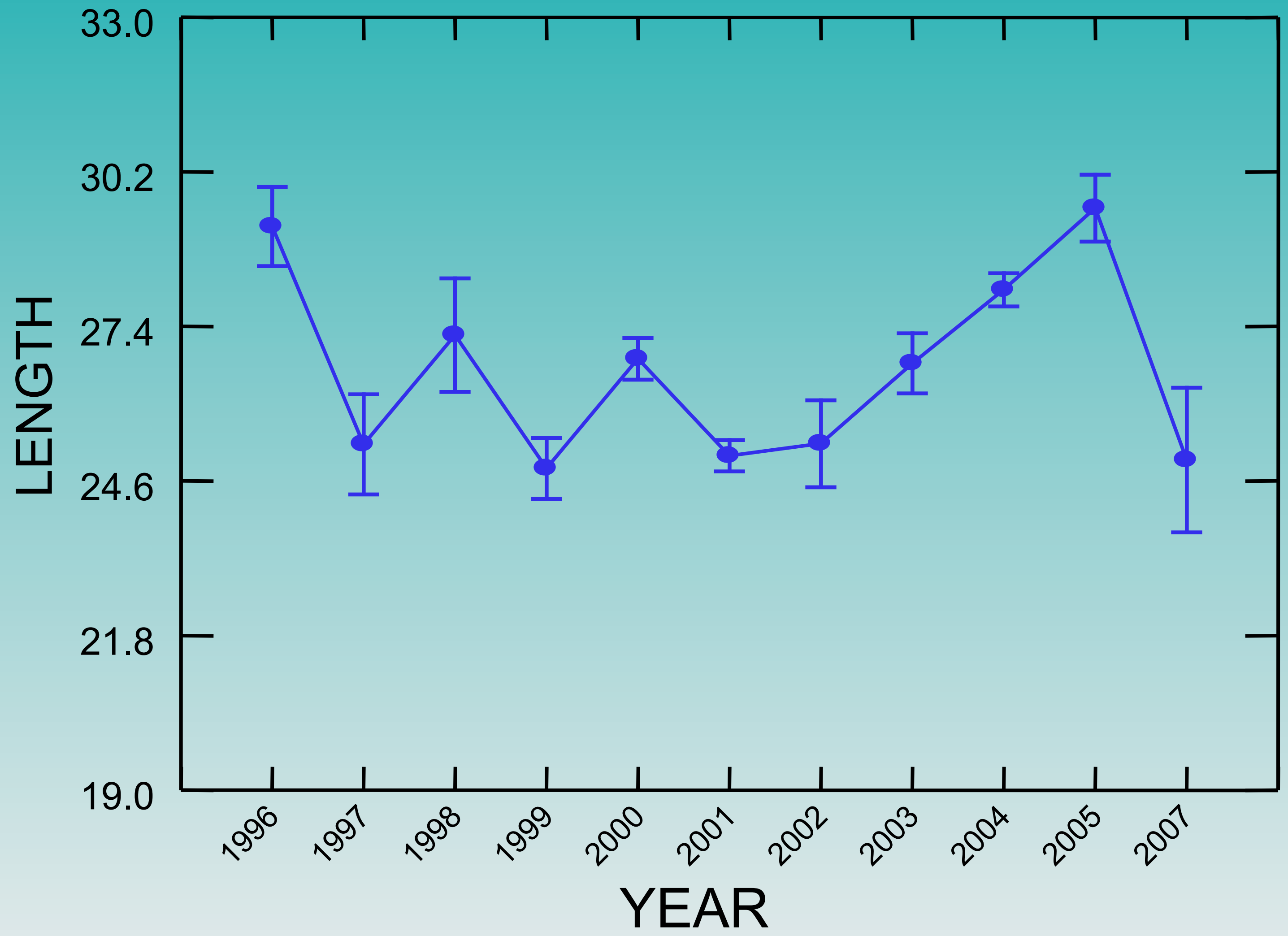
- Flathead sole were significantly greater in abundance in 2001 than all other years except 2002 and 2005 ($p < 0.02$)

- Although P. cod abundance appears greatest in 2005, it was not significantly greater than 1996, 2000, 2001, or 2003.

- N. rock sole were significantly greater abundance in 1997, 2001, 2005, and 2007

Walleye pollock – Lengths

Least Squares Means



ANOVA – Lengths

- Size of walleye pollock in 1996 and 2005 was significantly larger than all other years (1996 $p < 0.003$, 2005 $p < 0.001$) but not different from each other

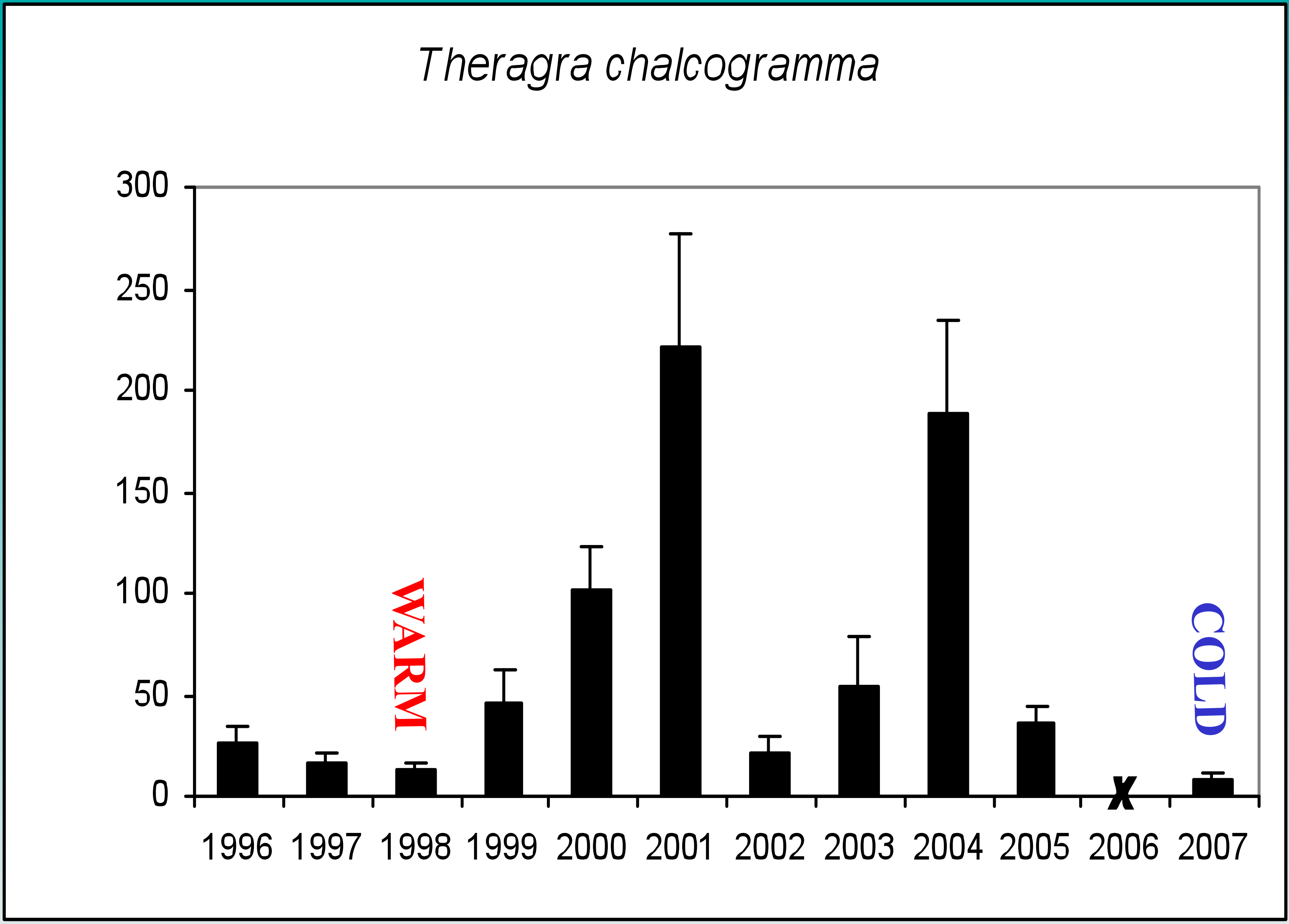
- Size of walleye pollock in 2004 was significantly larger than all other years with the exception of 1996 and 2005 ($p < 0.003$)

- Significant differences were also detected between years for Pacific cod, ATF/KF, Flathead sole, and N. sock sole but lacked any consistent pattern.

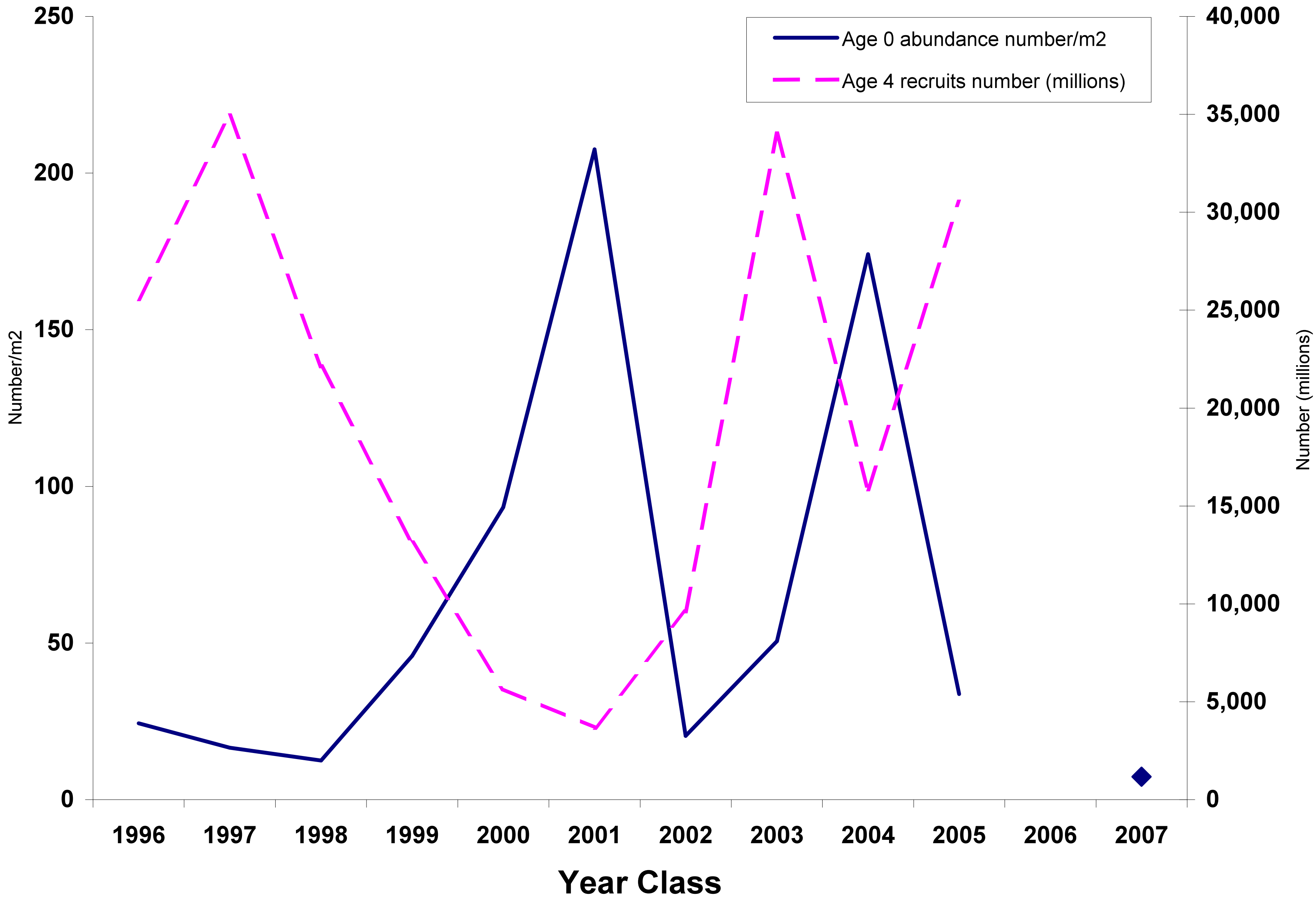
"Top 10 Lists"

1996-2000	2001-2007
Theragra chalcogramma	*Theragra chalcogramma*
Hippoglossoides elassodon	*Hippoglossoides elassodon*
Gadus macrocephalus	*Gadus macrocephalus*
Atheresthes spp.	*Lepidopsetta polyxystra*
Lepidopsetta polyxystra	*Ammodytes hexapterus*
Ammodytes hexapterus	*Atheresthes* spp.
Lumpenus maculatus	*Liparis* spp.
Reinhardtius hippoglossoides	*Podothecus veternus*
Sebastes spp.	*Lepidopsetta bilineata*
Zaprora silenus	*Lumpenus maculatus*

Lists are based on average abundance (catch/10m^2) at the 12 common stations sampled in all 11 years.



Theragra chalcogramma
300
250
200
150
100
50
0
WARM
COLD
x
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007



Age 0 abundance number/m2
Age 4 recruits number (millions)
Number/m2
Number (millions)
250
200
150
100
50
0
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year Class

Conclusions

- Species composition in 2001 and 2007 were different from each other and all other years
- Differences attributed to widely different abundances of walleye pollock and elevated abundances of N. rock sole and snailfishes in 2007
- Assemblages appear to be more structured according to hydrography in cold years
- Abundances of Walleye pollock, Flathead sole, and P. sand lance generally increased during “warm” period then declined

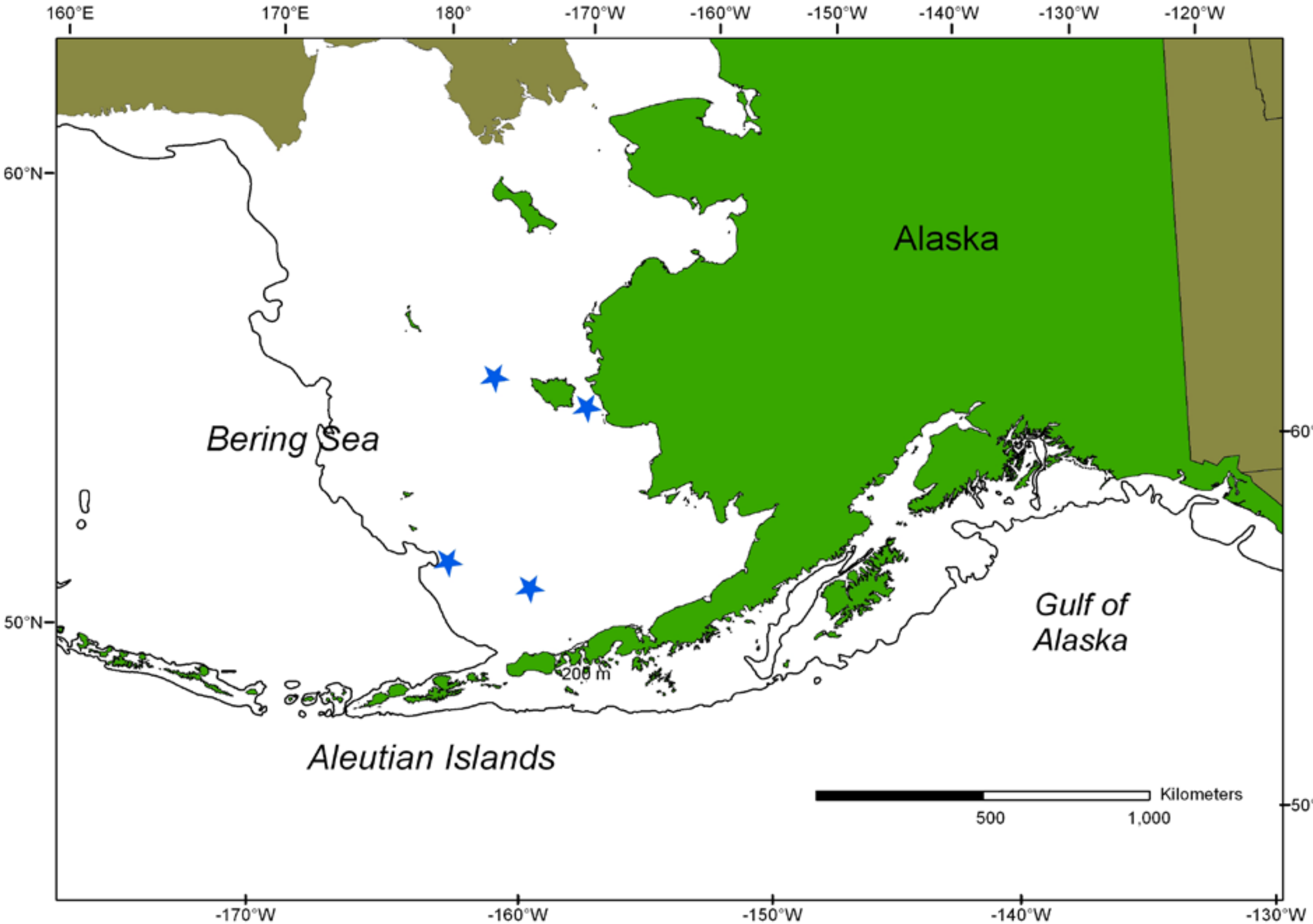
What next?

BIOENV

Which physical variable(s) most influenced the observed species composition?

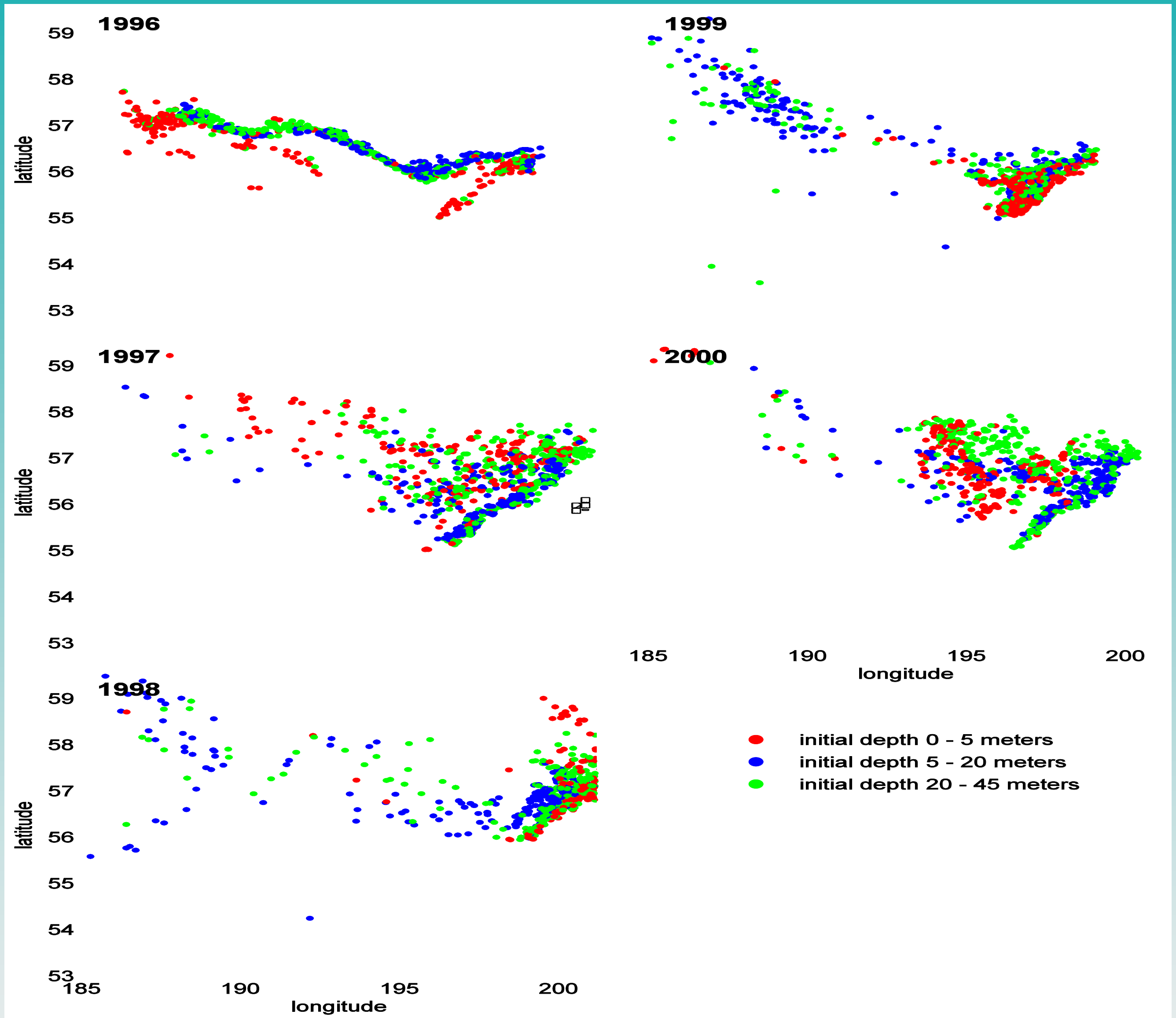
6 Variables

1. Bottom Depth - Hydrography
2. Temperature
3. Salinity
4. Percent Sea Ice Coverage
5. Date of Last Winter Storm
6. Max. Wind Speed in Last Storm



160°E
170°E
180°
-170°W
-160°W
-150°W
-140°W
-130°W
-120°W
60°N
50°N
Alaska
Bering Sea
Gulf of
Alaska
Aleutian Islands
200 m
Kilometers
500
1,000
-170°W
-160°W
-150°W
-140°W
-130°W

What next? - Drifter Trajectory Models



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- **A. Matarese, J. Napp, K. Bailey - NOAA/AFSC**
- **N. Bond, S. Salo, P. Stabeno, N. Kachel – NOAA/PMEL, UW**

PLANKTON LABORATORY

HOKKAIDO UNIVERSITY HAKODATE

T/V *Oshoro Maru*

Summers of 1995-2007

Participant - 1996, 1997, 2007

Marine Ecological Studies in the Bering Sea and Eastern North Pacific Ocean

A Mini-Symposium to mark the 2001 cruise of the T/S *Oshoro maru*

July 11, 2001

University of Washington
School of Aquatic and Fishery Sciences building